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ABSTRACT

Drawing from a review of the literature and direct experience, this paper discusses key issues in developmental mathematics placement. First, the controversial practice of mandatory placement is examined, citing research results that support the practice and those that do not. Next, the diversity of developmental math placement standards is considered, reporting on studies that describe various methodologies for setting cut scores. In considering the question of test format, the paper touches on the pros and cons of multiple-choice placement testing and notes developments in open-ended response formats. The issue of test administration is also addressed, with particular focus on speededness, computer-based testing, and calculator use. The final sections deal with the special needs of women and minorities related to placement testing and policies, and highlight cooperative efforts of high schools and colleges to encourage high school students to learn more precollege mathematics. Concluding comments identify other relevant issues that warrant further attention. A 44-item bibliography is included. (AC)

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REVIEW OF

# RESEARCH in Developmental Education

*Gene Kerstiens, Editor*

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## Selected Studies on Math Placement

By Geoffrey Akst and Lewis Hirsch

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# Selected Studies on Math Placement

By Geoffrey Akst and Lewis Hirsch

Placement — the process of determining where students belong within a sequence of courses — is one of the pillars on which a developmental program rests. This is particularly true in mathematics, with its hierarchical and carefully delineated course content.

In this monograph, we examine some issues in developmental math placement. Based on our direct experience and a review of the literature, we consider these issues interesting from the standpoint of laying the groundwork for effective placement and pointing the way to promising placement innovations.

The issues with which we deal are: mandatory placement, placement standards, test format, test administration, special student needs, and articulation with the high schools. We begin with the question of whether placement into developmental math courses should be compulsory.

## Mandatory Placement

Especially in mathematics, the consequences of misplacement can be devastating for the student. Whether or not the college should assume the burden of enforcing its placement decisions is therefore a serious matter.

Some colleges leave the final decision to the student, while others take a more paternalistic approach. Lewenthal (1981) writes of four models with respect to the issue of mandatory placement: self-assessment, in which students are provided with take-home tests and then decide the course in which they should enroll; advisement, in which counselors make a recommendation to students as to the most appropriate course; mandatory placement, in which a placement unit makes course assignments that are binding on the student, possibly allowing borderline students to choose between alternatives; and modified mandatory placement, in which the recommendation is taken as binding unless the student obtains a waiver from a designated advisor.

Various observers have argued in favor of mandatory placement. Sworder (1986), for example, observed that ill-prepared and ill-informed students often make poor academic choices. Akst and Ryzewic (1985) suggested that mandatory placement may reflect less a distrust of student judgment than a sense of institutional commitment. And a Washington State Student Services Commission Report (1985) took the position that an institution which "allows or advises academically underprepared students to enter college-level courses is effectively closing the door to their success" (p. 1).

A college which chooses to make its placement decisions mandatory has a particular obligation to establish the validity of its placement procedures. Validity studies of placement measures usually include (multiple) regression or similar analyses. These analyses use one or more of the following dependent variables: grade point average (Romero, 1988; Brooks, 1985), persistence (Zerr, 1986), and performance in college-level math courses (Case, 1987; Helmick, 1983; Hunt, 1987; Kenison, 1986; Maxwell, 1988; McFadden, 1986). In these studies, correlations are usually significant, but not high, since performance based upon these measures can be influenced by many factors including the student's innate ability, previous achievement, motivation, finances, health, overall schedule, and preferred learning style (Dennis, 1983; Palow, 1978).

Borst (1984) conducted an empirical study of the impact on students of adopting a system of mandatory assessment and placement; he found a significant overall improvement in grade point average and attrition rates following the imposition of the mandatory system. Results in a study conducted by the New Jersey Basic Skills Council (1988) also support the position that mandatory placement is effective: A state survey found that many colleges with mandatory placement reported comparable persistence, math grades, and grade point averages for remediated completers and nonremedial students.

By contrast, other research documents the extent to which colleges misclassify students, calling into question the placement system's validity. Such research is particularly damaging if that system is mandatory, although the results of these studies are frequently open to interpretation.

In one investigation of this type, Cuneo (1985) found that many of the students who took the remedial sequence at a major university were misclassified by the math placement test as underprepared. In another, Gabe (1989) investigated "skippers" — students who were supposed to take a developmental course but who instead took a college-level math course. This researcher found that a third of them successfully completed the college-level course.

A study by Hoelzle (1988) to some extent diffuses the opposition to mandatory placement. He examined a nonmandatory math placement system in a two-year college, and found that over 70% of students wound up enrolling in the courses recommended by advisors.

While our review of the literature has not uncovered sufficient evidence to conclude that mandatory placement is preferable for all programs, it does suggest that whether such a policy should be instituted depends upon a number of factors. These include: the validity of the placement instrument, the quality of advising, and the nature of the student population.

## Placement Standards

The literature of developmental mathematics provides ample evidence that math placement standards vary significantly from college to college. For example, a regional survey of several hundred institutions in the American Southeast documented a large number and variety of tests employed at responding institutions — tests which measure disparate abilities and skills (Abraham, 1986). This survey also found among the respondents markedly divergent cut scores, indicating a wide range of placement criteria.

This variation in cut scores — the standards against which colleges make placement decisions — stems in part from a lack of consensus as

to how they should be set and which particular variables we are trying to maximize or minimize. The literature describes and compares numerous methods, ranging from faculty judgment to percentile analyses, from scatter diagrams to regression techniques (Hector, 1984; Hills, Hirsch, & Subhiyah, 1987; Lewenthal, 1981; Pearse, Agrella, & Powers, 1982; Weber & Twing, 1986). Hovcland (1985) alone describes the application of five different methods of determining cut scores for a math placement exam. Collectively, these studies make for a wide array of options, with none having commanded total acceptance.

## Test Format

In-class math tests generally consist of open-ended questions. Yet math placement tests nearly always follow a multiple-choice format.

In defending the use of multiple-choice tests, advocates argue that they reliably predict subsequent in-class performance —the standard against which to judge placement instruments. Other researchers, however, view the use of multiple-choice placement exams more skeptically. They attribute this practice to expediency and economy and condemn multiple-choice placement exams for encouraging poorly prepared students to guess and to devalue their own reasoning and problem-solving ability (Cobb, Pereira, Krishnamachari, & Soto, 1990; Gougeon, 1984; Noreen, 1987).

Critics of multiple-choice placement exams should applaud the College Board's recently announced plan to modify the format of part of its S.A.T. admissions test (DePalma, 1990). Future S.A.T. math sections will purportedly include open-ended items in response to which students must enter their answer on a machine-scorable answer sheet. If this innovation turns out to be widely applicable—combining the desirable qualities of both multiple-choice and open-ended formats — it may well sweep the field in future math placement testing.

## Test Administration

How a test is administered can also significantly affect student scores and therefore test validity. Three issues relating to the administration of math placement tests are: speededness, computerized testing, and calculators.

Speededness, while widely discussed in the literature of reading assessment (Kerstiens, 1990), has received less attention in mathematics. There seems to be a wide acceptance of the general content of mathematics, and the items used to measure this content on placement tests have been at a low enough level for students to be able to move quickly through these tests, especially those with multiple-choice format. However, changes currently proposed by national organizations in the emphasis and direction of the math curriculum as well as in testing practice will make speededness an important factor in test performance. It is critically important to give students a reasonable amount of time to take a math placement test. Psychometricians have recommended that if a test is not to be considered speeded, 80% to 90% of the examinees must complete the test (Nunnally, 1978).

By contrast, a second administrative issue — that of using computers to administer exams — has received wide attention in mathematics circles. Advantages of going "on-line" include: briefer tests, shorter testing time, fewer security problems, and more rapid scoring. The main disadvantages are the need for special equipment, software, space, and designated examinee scheduling.

Ward, Kline, and Flaugher (1986) investigated the predictive validity of the College Board's new "computerized adaptive" placement battery. In their study, the target population was some 2,500 students at 17 colleges and universities. The correlations between math end-of-term grades and math test scores seem promising, suggesting that these scores can contribute significantly to a student's placement profile. Many questions remain concerning the use of computer-administered tests. What is clear is that this issue is likely to come to a head as microcomputers become available on campus in sufficiently large numbers to make computer-based placement testing feasible.

Another key administrative issue is whether calculators should be allowed on placement exams. Both the National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) have issued supportive statements, and a number of colleges already allow students to use calculators on their math placement exams. While a procalculator policy remains controversial, it may well be the wave of the future (Bennett & Whittington, 1986).

Harvey (1989) cautions that not permitting calculators on college math placement tests may negatively bias the assessment of a student's mathematical achievement, especially if that student expects to use a calculator but is disallowed the opportunity. He also notes that scores on tests that forbid the use of calculators may not accurately predict a student's ability to succeed in math courses which encourage their use.

On the other hand, Harvey (1989) warns that the particular calculator model that students use during testing — whether it is programmable, whether it graphs functions, etc. — is very important. He stresses the difficulty in ensuring that every student tested has access to an appropriate calculator. Other authors raise additional concerns relating to unhealthy dependence, equity, security, and practicality.

A study by Leitzel and Waits (1989) reports on their experience at Ohio State University, where all freshman math courses *REQUIRE* (and the university placement exams *PERMIT*) the use of calculators. The authors note that in comparison with traditional placement exams, the Ohio calculator-based exams deal with more realistic numbers, test for processes as well as for numerical answers, and stress graphing. An examination of past test results shows that students who chose to use calculators had stronger math backgrounds and earned higher scores. On some items — particularly those involving computation — students using calculators did much better than nonusers; on other items, the reverse held.

If the recommendations of recent reports such as the NCTM Standards are implemented, we expect to see greater attention paid to the three administrative issues of speededness, the use of calculators, and the use of computers.

## Special Student Needs

A number of recent studies have focused on the needs in developmental math programs of women and minority students. These studies raise important issues -- what special needs do various groups of students demonstrate? To what extent should developmental placement programs accommodate these needs?

In one such study, Cox (1981) investigated the impact on 500 community college students of instituting placement and advisement procedures. He found that these procedures were more important for the success of Afro-American and Hispanic students than of Caucasian students. And in a survey of two-year colleges, Woods (1985) found that mandatory testing for course placement was most prevalent in institutions with significant minority populations.

Cossio (1977) explored the relationship between placement test scores and linguistic ability; she noted that many Hispanic students do better on a math placement test given in Spanish than in English — an obvious conclusion but one with significant implications for both math placement and instruction.

Gougeon (1984) criticized the use of standardized math tests which, because of out-of-date norms based on an insufficient number of women and low-income students, have low predictive validity.

Porter (1986) analyzed the placement records of a community college cohort for gender-based disparities and found a male advantage in math placement test performance. By contrast Maxwell (1988), after controlling for math backgrounds, found no overall difference at a major university in placement scores between men and women.

What seems clear is that the importance of questions such as these, of exploring ways to identify and to meet special student needs, will only grow as the clientele which our institutions serve continues to become more diverse. In particular, colleges should reexamine the

validity of their placement tests and placement policies with respect to their diverse populations.

## Articulation with the High Schools

The past decade has seen a number of postsecondary institutions taking initiatives aimed at shifting the teaching of precollege mathematics back to the secondary school. This shift is achieved by administering to college-bound high school students an early college placement test so as to provide them with the most appropriate math instruction.

Several articles describe the widely emulated "prognostic testing" initiative begun at Ohio State University (OSU) in the late 1970's (Adcock, Leitzel, & Waits, 1981; Kiltinen, Hirst, & Joyal, 1987; Leitzel & Waits, 1989). After high school juniors took the OSU placement tests, their schools informed them of the math placement which they would have earned had they been entering OSU at the time. The hope was that this information would encourage students to schedule an appropriate senior-year math course. Since the OSU initiative began, senior-year math enrollments increased dramatically, and participating students, after graduating and entering OSU, earned significantly higher placements than had comparable students of the past.

Thompson (1981) reports on a similar undertaking at the University of Arizona. This program informed state high schools how their graduates had performed on the university placement exam, providing each school with valuable evaluative data.

Such efforts reflect a growing awareness that it is in the interest of everyone concerned for colleges to encourage high school students to learn more precollege mathematics.

## Conclusions

This discussion of key issues in developmental math placement and the associated literature has barely scratched the surface. We have looked at the controversial practice of mandatory placement, noting various research results -- some supportive and others not. We have reported on the diversity of developmental math placement standards, citing studies which describe various methodologies for setting cut scores. In considering the question of test format, we have touched on the pros and cons of multiple-choice placement testing, and noted developments with respect to the open-ended response format. We have also examined issues of test administration — speededness, computer-based administration, and calculator use — and scanned some recent research bearing on the math placement needs of special student populations.

In addressing if only in the briefest terms all these concerns, we have ignored a host of others. These include but are not limited to: strategies for gauging test validity, criteria for choosing between locally developed and commercially distributed tests, the evaluation of placement programs, desirable placement procedures, and differences between math and language placement. Investigators in developmental education seeking stimulating and useful research topics would do well to consider any of the above.

Overall, our feeling is that the value of studying the literature of developmental math placement lies less in settling issues than in raising them. We believe that the best of this research — both empirical studies and position papers — has the potential of forcing the reader to confront neglected problems, to see new points of view, to question basic assumptions, and to consider the adoption of new models and technologies.

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